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20 September 1983

# USSR Report

ELECTRONICS AND ELECTRICAL ENGINEERING

No. 114

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ELECTRONICS AND ELECTRICAL ENGINEERING

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ANTENNAS AND PROPAGATION

UDC 621.391.83:621.397.13]

ANALOG AND DIGITAL SYSTEMS FOR CORRECTION OF TIME-BASE DISTORTIONS OF  
TELEVISION SIGNALS

Moscow TEKHNIKA KINO I TELEVIDENIYA in Russian No 6, Jun 83 pp 43-46

ZELENIN, I. A., Moscow Institute of Electrical Engineering of Communications

[Abstract] Analog and digital correction of time-base distortions in television signals is evaluated comparatively, for the purpose of determining the expediency of changeover to digital systems. Analog correction is continuous and adequate for time-base errors not exceeding 1-2 microseconds. Its advantages are high accuracy, because of smooth compensation by the control voltage, but its disadvantages are a narrow correction band and poor utilization of the total time delay. Digital correction is preferable in some cases, an analog signal with time-base distortion being discretized at a frequency equal to a multiple of the line frequency or the color subcarrier frequency and quantized in 256 levels before it is encoded. High speed of data transmission is attained by splitting the digital data flux into several parallel ones in a demultiplexer. The time-delay utilization factor depends on the method of data output from the memory. The correction band is relatively wide, theoretically unlimited, and no buildup of either distortions or interference occurs before digital-to-analog reconversion, even when the time delay is increased. The advantages of digital correction systems include also higher time stability and higher technological as well as economic indicators. Correction of  $\pm 20-30$  microsecond distortions is feasible with residual distortions in the output signal not exceeding  $\pm 1-3$  ns.

Figures 1; references 11: 7 Russian, 4 Western.

[269-2415]

BROADCASTING/CONSUMER ELECTRONICS

UDC 621.317.765

GENERATOR OF TEST SIGNALS

Moscow TEKHNIKA KINO I TELEVIDENIYA in Russian No 6, Jun 83 pp 57-58

BORODYANSKIY, A. A. and PRUSOVSKIY, S. I., Ryazan Institute of Radio Engineering

[Abstract] A digital generator of television test signals has been designed and built using series K500 microcircuits, with programmable read-only memory and conversion of code combination sequences to analog signals. The generator produces one brightness and two color signals (R-Y, B-Y) as well as steep linear transients. The read-only memories, one in each of the three channels, are built with K500RYel49 microcircuits and form 256 8-digit words. Each channel contains also a K500PUL25-microcircuit TTL forming parallel codes and a K594PAL-microcircuit D/A converter with a 159NT1B-transistor current amplifier loaded by a low-pass filter at the output. The generator is controlled by a K500LM105-microcircuit logic and a K500IYel36-microcircuit 8-digit reversible counter. The generator performance characteristics are high speed, with total time delay (not including low-pass filters) of 80 ns, rise time of 25 ns, and timing instability not exceeding 5 ns. The possibility of switching of changing the programmable read-only memories makes this generator universal with respect to signal structure and adaptability to any space-time test table. Figures 1; tables 1; references: 2 Russian [269-2415]

UDC 621.397.61

BROADCASTING TELEVISION TOWARD END OF CENTURY

Moscow TEKHNIKA KINO I TELEVIDENIYA in Russian No 6, Jun 83 pp 3-9

PEVZNER, B. M., All-Union Scientific Research Institute of Television

[Abstract] Developments in broadcasting television during the coming 20-25 years are forecast on the basis of the present state of the art and innovations already in progress. It is certain that by the year 2000 broadcasting television in the USSR will be based on the standard SECAM 625/25 system, with broadcasting in color exclusively after the year 1990. Improvements will

be made in receiver sets and in broadcasting centers. Such improvements will include vertical filtration of color-difference signals for elimination of horizontal flicker, use of subcarrier frequencies for suppression of cross-talk distortions, synchronous detection for suppression of quadratic distortions, and interference-immune digital FM detection. The new television system will be designed optimally, remaining compatible with the present system during transition and adaptable to a single worldwide ("global") broadcasting standard. Receiver screens will be wider, closer to the size of movie screens, which will require introduction of plane arrays with appropriate line spacing and density. Signal transmission will be completely digital, with rates of the order of 1000 MBit/s, up to the receiver screen. Reception will be converted to stereoscopic, both video and audio, with a high degree of automation at the television center. The trend is toward reduction of necessary equipment and personnel, replacement of two-step switching with high-capacity high-speed switch arrays, simplification and better utilization of expensive devices, and expansion of local cable television networks. Complete conversion to solid-state photoelectric converters by the year 2000 is difficult to predict, because the development of Plumbicons for transmitter cameras is still problematic, rather a coexistence of tube and solid-state fifth-generation equipment is anticipated. References 18:

9 Russian, 9 Western.

[269-2415]

UDC 621.385.832.82

#### CHARACTERISTICS OF TRANSCRIPTION OF FREQUENCY-MODULATED SIGNAL ONTO CATHODE-RAY STORAGE DEVICE

Moscow TEKHNIKA KINO I TELEVIDENIYA in Russian No 6, Jun 83 pp 47-50

KOMAROV, V. A., Moscow Electrical Engineering Institute of Communications

[Abstract] Cathode-ray storage devices are eminently suitable for delaying video signals in television for lengths of time which depend on the length of the field and frame. The most effective method of eliminating non-uniformities in the storage readout signal is transcription of the input signal by means of frequency modulation rather than amplitude modulation, because in the latter case automatic level control prevents complete suppression of multiplicative interference. The modulation band must be inscribable into the vidicon aperture characteristic, which requires a low carrier frequency and subsequent demodulation by the frequency doubling method. The problem of interference immunity is solved by separation of the recording channel and the readout channel, with correction of high-frequency predispositions as well as suppression of multiplicative interference in the former and correction of aperture distortions in the latter. In the recording channel the signal is frequency modulated with "phase binding" and additive interference is suppressed by quenching pulses. In the readout channel the signal is demodulated and the carrier is restored in the quenching interval during the beam return stroke so that no information becomes lost. An

experimental evaluation of this system with an LI418-1 vidicon serving as the storage tube has revealed that the signal-to-noise ratio increases with increasing upper frequency of the FM signal, as the peak power in the FM spectrum shifts toward the falling range of the aperture characteristic. The amplitude of the readout signal can be stabilized by means of feedback.

Figures 4; references: 9 Russian.

[269-2415]

UDC 771.447:326.546.12]:778.588

#### NEW TUNGSTEN-HALOGEN LAMP FOR FILM PRINTING EQUIPMENT

Moscow TEKHNIKA KINO I TELEVIDENIYA in Russian No 6, Jun 83 pp 28-32

BEOLOVA, I. D., NAZAROV, S. Kh., PIYAVSKIY, V. F. and YAVNO, I. O., All-Union Scientific-Research Institute of Light Sources imeni A. N. Ladygin, Central Motion-Picture Design Office of Scientific-Industrial Association "Efran"

[Abstract] A new incandescent lamp has been developed for movie projectors and film printers which retains constant light-and-color characteristics throughout its useful life. Its cylindrical bulb, made of optical pure quartz glass, is filled with spectrally pure nitrogen to a pressure of 2,000 mm Hg with a 12 mm Hg addition of methylene bromide. The tungsten filament is wound into a "biplan" spiral 11.8 mm high by 10.8 mm wide and connected to a G17t base. The lamp operates according to the principle of a regenerative halogen-tungsten cycle, blackening of the bulb being prevented by tungsten vapor. This KGM120-1200 lamp delivers at least 36,000 lm with 44-46 Mcd/m<sup>2</sup> at nominal voltage (120 V) for the first 12 hours and 90% of that for the remainder of its life, the mean life being 15 h with a color temperature of 3400 K. The performance and basic design characteristics of this lamp are similar to those of the smaller KGM40-750 and KGM48-1000 versions and comparable with those of both BTG and BRR lamps manufactured by Sylvania Co. (Technical data on these four lamps is presented.) The KGM120-1200 is already in series production at the "Svetlotekhnika" plant in Saransk for use in 25AM0-1, 23TT0-3, 23UT0-3, 23MT0-1, 23KTK-2 and 23ETO-1 film printers.

Figures 6; tables 3; references 5: 4 Russian, 1 Western.

[269-2415]

SECOND SCIENTIFIC AND TECHNICAL CONFERENCE ON PROBLEMS OF ELECTROMAGNETIC COMPATIBILITY OF POWER-SEMICONDUCTOR CONVERTERS

Moscow ELEKTRICHESTVO in Russian No 5, May 83 pp 76-77

TAMKIVI, P. I.

[Abstract] The second conference on Problems of Electromagnetic Compatibility of Power-Semiconductor Converters was arranged by the Science Council of the USSR Academy of Sciences and by the Institute of Thermophysics and Electrophysics at the ESSR Academy of Sciences, within the context of "Scientific Principles of Electrophysics and Electrical Power Engineering." In the conference participated over 150 specialists from 60 scientific research and engineering design organizations as well as higher educational institutions. The topics covered in the presentations were evolution and solution of compatibility problems, including technical as well as biological and economic aspects, establishment of interrelated norms for interference emission and reception by electrical equipment, electromagnetic compatibility of converters with the power supply network, experience in the Soviet Union and abroad with production and application of thyristor-type kvar compensators, latest high-grade power-thyristor converters, design of passive and active filters for a.c. and pulse-type d.c. converters, achievements in electromagnetic compatibility in self-contained power modules, original new means of improving the electromagnetic compatibility by better control of components, effect of power-semiconductor converters on data transmission systems, effect of rectifier loads on protective relaying and automation systems, problems of producing nondistorting converters, special features in the performance of capacitor banks in power filters, and application of computer techniques to compatibility analysis and design, to problems such as digital control of frequency converters by means of pulse-width modulators and rectifiers. Recommendations adopted at the conference on the basis of these reports and their discussion indicate that the problem of electromagnetic compatibility of power-semiconductor converters has become much more serious and its solution much more urgent since the first conference on the subject.

[285-2415]

CIRCUITS AND SYSTEMS

UDC 621.372

OPERATIONAL INPUT MACROINSTRUCTION LANGUAGE FOR CIRCUIT DESIGN

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 26, No 6, Jun 83 (manuscript received 25 May 82) pp 89-90

ARKHANGEL'SKIY, A. Ya. and LEVSHIN, N. G.

[Abstract] The high-level input language ELAIS has been written for computer-aided circuit design. The two basically contradictory requirements of adequate versatility and adequate complexity are satisfied by inclusion of means to formalize and set up known procedures for any given class of problems. Any functions and arithmetic expressions can be put in this language, which also included a computation cycle operator for evaluating necessary relations and a set of call-out operators for performing various tasks such as transient analysis, macromodel design, target function evaluation, and parametric optimization. The set of procedure call-out operators constitutes the macroinstruction language, with one procedure including the call-out of another so that the complete set of necessary computations can be made. The language provides for storage of results for a buildup of design experience.

References: 2 Russian.

[273-2415]

COMPUTERS

UDC 621.372.412

STABLE ALGORITHM FOR DIGITAL COMPUTER SIMULATION OF NATURAL VIBRATIONS OF  
HIGH-FREQUENCY QUARTZ RESONATORS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 26, No 6, Jun 83 (manuscript received 16 Jul 82) pp 27-32

VESELOV, G. I., POSTNIKOV, I. I. and SAMOYLOV, V. S.

[Abstract] Most quartz resonators produced for frequencies from 100 kHz to 300 MHz, approximately 80% of all, have piezoelectric sensing elements designed for shear vibrations in thickness. Simulation of their performance on a digital computer requires the solution of a system of M second-order partial differential equations with variable coefficients for the displacement function, in cylindrical coordinates for an axisymmetric element. With the displacement function expanded into a trigonometric series, this system can be reduced to one of M ordinary differential equations, each coefficient intricately depending on the radius of the element. The boundary conditions match a particular vibration mode and the initial conditions determine the particular solutions. This system can be further reduced to a homogeneous one of linear algebraic equations. For determining the natural vibrations, its determinant is equated to zero and the corresponding boundary-value problem is reduced to a Cauchy eigenvalue problem. For an element with a small curvature (without localization of large vibration amplitudes and fast decay toward the periphery) it is permissible to use the algorithm of the elimination method of solving, at each node of the grid, a system of M algebraic equations of an order N times lower than in the straight-forward N-point finite-difference method. It is preferable to start the numerical integration from the center toward the periphery. Stability of the solution will be ensured when the diagonal elements in the cofactors matrix are dominant. A stable algorithm and an unstable one are demonstrated on the calculation of eigenfunctions for a plane-convex piezoelectric lens. The stable one has been programmed in FORTRAN-4 for Yes Unified System computers. Figures 3; references: 7 Russian, 1 Western (in translation)  
[273-2415]

UDC 621.387.3

PERFORMANCE OF DATA DISPLAY DEVICE BUILT WITH GAS-DISCHARGE TUBES ON INDICATOR PANEL

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 3, Mar 83 (manuscript received 15 Dec 81) pp 46-49

SVIYAZOV, A. A. and SMOLYAROV, A. M., Ryazan Institute of Radio Engineering

[Abstract] The performance of a data display device consisting of gas-discharge tubes on an indicator panel is analyzed by a simple method, assuming that the tubes form m rows with a fixed number of n character arrays in each. For the purpose of reliability analysis, all elements of the display device are classified into two groups:  $G_T$  elements (components of clock-pulse generator and pulse distributor) whose failure causes complete failure of the panel and  $G_R$  elements (components of memory register, anodic switches, and main memory) whose failure causes failure of their row only. Calculations on this basis reveal that, for higher efficiency of such a display device, the number of elements of each group should be minimized and the alphabet of characters should be optimized accordingly. The relative efficiency increases with increasing number of rows whose simultaneous failure will cause complete failure of the device. The paper was recommended by the Department (Kafedra) of Automatized Control Systems. Figures 2; references: 4 Russian.

[278-2415]

UDC 681.3

COMPARATIVE EVALUATION OF SOME DIAGNOSTIC ALGORITHMS WITH RESPECT TO SPEED IN INFORMATION AND MEASUREMENT SYSTEMS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 3, Mar 83 (manuscript received 20 Oct 82) pp 38-42

KOVALEV, B. M., Kuybyshev Institute of Structural Engineering imeni A. I. Mikoyan

[Abstract] Algorithms of dichotomy for diagnosing the state of inspection and control objects are the fastest but require a complex recognizer automata structure, while the algorithm of passive sorting is the simplest but also a very slow one. An algorithm of "segmentation" has been proposed which combines passive sorting with dichotomy. The recognizer automata for this algorithm reduce to a recalculation scheme with forced setting of its initial state. This algorithm is evaluated and compared with the other two in terms of speed in a typical diagnostic situation, where the inspection object moves over a state space but can be only in one element of this space at any instant of time. The mean diagnosis time is calculated for all three algorithms. The results suggest that the "segmentation" algorithm is most expedient for an object in a state space of low dimensionality. When the access time to the

object is short, the speed of this algorithm can be increased by insertion of a direct-access memory into the recognizer automata module. The paper was recommended by the Department (Kafedra) of Applied Mathematics and Computing Techniques. Figures 1; references 4: 3 Russian, 1 Western (in translation). [278-2415]

ELECTRICAL INSULATION

UDC 621.315.611:537.311.3

MECHANISM OF SURFACE CONDUCTION IN SOLID DIELECTRICS

Moscow ELEKTRICHESTVO in Russian No 5, May 83 (manuscript received 6 Jun 82)  
pp 51-54

SOBOLEV, V. G., candidate of technical sciences, Kalinin Polytechnic Institute

[Abstract] One important property of a dielectric material determining its life as insulation is its electrical surface conductivity. In order to predict this property for reliability analysis and life estimates, it is necessary to know the mechanism of surface conduction under actual operating conditions. Experiments have established that a water film builds up on the dielectric surface in a humid atmosphere and, with dissolved salts and bases, becomes the main source of high conductivity. Thermodynamic relations in this nonhomogeneous adsorbate layer and characteristics of the subsequently formed electric double layer are described by the Helmholtz and Smolukhovskiy-Stern theories. An expression for the electrical surface conductivity is derived accordingly, with the aid of Brunauer-Emmet-Taylor, Frenkel-Halsey-Hill, and Bickerman equations. Calculations reveal that in a highly humid atmosphere the electric double layer and the free solution contribute to the total electrical surface conductivity, in a ratio depending on the concentration and the water vapor pressure, thus also on the temperature, as well as on the structure and the properties of the dielectric surface. Numerical data are obtained for various solid dielectric insulation materials (press-board, epoxy compound, glass-Textolite). For reference, the conductivity of water with various concentrations of KCl is compared with that of pure (distilled) water. Figures 3; tables 2; references 11: 9 Russian, 2 Western (both in translation).

[285-2415]

ELECTROMAGNETIC COMPATIBILITY

UDC 621.371.32:538.552.2.001.24

CALCULATION OF ELECTROMAGNETIC FIELD PRODUCED BY GROUP OF SOURCES

Moscow IZVESTIYA AKADEMII NAUK SSSR: ENERGETIKA I TRANSPORT in Russian  
No 3, May-Jun 83 (manuscript received 10 Feb 82, after revision 19 Oct 82)  
pp 84-90

APOLLONSKIY, S. M., Leningrad

[Abstract] Calculation of the electromagnetic field of a group of sources in free space by the superposition method in an orthogonal curvilinear system of coordinates is corrected by taking into account interaction of sources in the group, this interaction and the corresponding correction being dependent on the distances between sources. Appropriate corrective functions for the resultant vectors of electric and magnetic field intensity are given which apply to low-frequency sources (below 5 kHz). The simplest case of two sources is considered first, then the general case of many sources in a group. Theoretical results are compared with experimental ones. In the experiment field intensity measurements were made first with two and then with three hollow brass spheres (outside diameter 0.31 m, wall thickness 0.002 m, electrical conductivity of material  $\sigma = 57 \cdot 10^6 \text{ ohm}^{-1} \cdot \text{m}^{-1}$ ), each containing a coil of 1200 turns with an alternating current of 3 A - 50 Hz. The center-to-center distances between the spheres was varied, three spheres were always placed at corners of a rectangle in the plan view and the field measured as well as calculated at the fourth corner. A comparative evaluation of numerical data indicates that this method of corrective functions is adequate for determining electromagnetic interference and compatibility where diverse electrical equipment has been installed. Figures 2; tables 2; references: 9 Russian.

[281-2415]

ELECTRON DEVICES

UDC 621.315.592

EFFECT OF COMPENSATION ON EDGE LUMINESCENCE OF STRONGLY DOPED GALLIUM ARSENIDE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 17, No 4, Apr 83  
(manuscript received 29 Oct 82) signed to press 23 Nov 82) pp 607-610

ARNAUDOV, B. G., DOMANEVSKIY, D. S., YEVTIMOVA, S. K., ZHOKHOVETS, S. V.  
and PROKOPENYA, M. V., Belorussian Polytechnic Institute, Minsk

[Abstract] Studies were made of the edge photoluminescence of n-GaAs structures simultaneously doped with fine donor (Te) and acceptor (Ge) impurities during epitaxial growth, in amounts ensuring a constant electron concentration  $n = 2 \cdot 10^{18} \text{ cm}^{-3}$  throughout the entire  $K = 0-0.7$  range of compensation. In the experiment photoluminescence was excited by means of a light beam from a 40 mW helium-neon laser. The rate of generation of excess electron-hole pairs was regulated by means of neutral filters and the photoluminescence spectra were analyzed with the aid of a grating-type monochromator with 4 meV resolution. Here the experimental results are compared with theoretical ones pertaining to the displacement of the spectral band toward longer waves with an attendant widening of the range of displacement energy and to the increase of the potential energy of rms impurity concentration fluctuation, all of which occur as the degree of compensation is increased. The results are interpreted in terms of a "moving" spectral band and a stationary spectral band, the Burstein-Moss spectral displacement, and the "degenerate conduction band - tail of valence band" theory. The results are also compared with those for singly doped GaAs<Te>structures. The photon energy at the peak wavelength in the edge band and the threshold energy for displacing the peak of the "moving" band have both been found to decrease as the degree of compensation increases. All the evidence suggests that interaction of fine donors and acceptors produces associates and deep states. Figures 2; tables 1; references 10: 7 Russian, 3 Western (1 in translation).

[279-2415]

## IMPLANTATION OF GALLIUM IONS INTO PbSe FILMS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 17, No 4, Apr 83  
 (manuscript received 10 May 82, signed to press 2 Dec 82) pp 611-613

ABROYAN, I. A., ALIYEV, B. Z., IMAMKULIYEV, S. D., KAZ'MIN, S. A.,  
 KAYDANOV, V. I., KASAMANLI, G. D. and SUVOROV, A. V., Leningrad Polytechnic  
 Institute imeni M. I. Kalinin

[Abstract] In an experimental study, 90 keV gallium ions were implanted into 0.7  $\mu\text{m}$  thick p-PbSe single-crystal films. The latter had been deposited on 0.1-0.3  $\mu\text{m}$  thick substrates with the [111] axis normal to the plane of the substrate and, after annealing at  $T = 300^\circ\text{C}$  for removal of radiative defects, had a Hall hole concentration  $p = (1.7-2.4) \cdot 10^{18} \text{ cm}^{-3}$  and a Seebeck coefficient of  $230-260 \mu\text{V}/^\circ\text{C}$ . The implantation was equivalent to bombardment with current pulses of 1.2 ms duration and  $1.7 \mu\text{A}/\text{cm}^2$  amplitude at a repetition rate of 50 Hz. Measurements have revealed a redistribution of the impurity concentration over the film thickness during implantation and subsequent annealing, also appreciable changes in electrophysical properties after the implantation dose has reached  $40 \mu\text{C}/\text{cm}^2$ . The impurity embedment depth increases, while the impurity concentration peak at the surface decreases, with increasing implantation dose and then decreases after annealing. At some high implantation dose both the Hall coefficient and the Seebeck coefficient reverse sign to become negative. The results agree reasonably well with those of theoretical calculations based on the three-layer model of such a film (n-layer of thickness  $d_1$  with exposed surface, space-charge layer a thickness  $d_2$  including the p-n junction, p-layer of thickness  $d - d_1 - d_2$ , total film thickness). This is demonstrated by curves depicting the embedment depth of the p-n junction and the relative change in the Hall coefficient as functions of  $N_{\text{Ga}} \beta / n_A$  ( $N_{\text{Ga}}$  - total number of Ga atoms per  $\text{cm}^2$ ,  $\beta$  - electrical activity of gallium in terms of electrons delivered by each atom,  $n_A$  - acceptor concentration). The authors thank G. M. Gur'yanov and A. P. Kovarskiy for performing the measurements by mass-spectrometry of secondary ions. Figures 2; tables 1; references 6: 5 Russian, 1 Western.

[279-2415]

UDC 621.315.592

DRAG OF CURRENT CARRIERS IN SEMICONDUCTORS BY PHOTONS IN FAR-INFRARED AND SUBMILLIMETRIC REGIONS OF SPECTRUM

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 17, No 4, Apr 83  
(manuscript received 12 Oct 82, signed to press 21 Dec 82) pp 698-703

GANICHEV, S. D., YEMEL'YANOV, S. A. and YAROSHETSKIY, I. D., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] An experimental study was made of the drag of current carriers in n-Ge and in -Ge by photons in the far-infrared and submillimetric regions of the spectrum. A tunable pulse laser on vapors of heavy water and ammonia serving as a radiation source pumped by a transverse-excitation atmospheric-pressure CO<sub>2</sub> laser (9.2-10.6 μm 10 J line energy) with ultraviolet preionization. The emitted radiation was polarized and its wavelength measured with a Michelson interferometer; it was varied over the 9.2-385 μm range with a pulse power up to 2 MW and pulse duration of (1-2)·10<sup>-7</sup> s. The p-Ge specimens were cut in the (111)-direction and their hole concentration was varied over the p= 10<sup>11</sup>-3·10<sup>15</sup> cm<sup>-3</sup> range. The n-Ge specimens had an electron concentration n= 3.5·10<sup>14</sup> cm<sup>-3</sup>. The spectra of the drag emf in both types of germanium and the dependence of this emf in p-Ge on the acceptor concentration reveal multiple spectral inversions in p-Ge, the drag emf and current reversing sign twice (60, 225 μm) at 300 K and three times (40, 80, 220 μm) at 78K, but there was no spectral inversion in n-Ge. The results are interpreted in terms of "direct" intersubband transitions, a decrease of the photon energy first causing the energy of initial states to approach the thermal energy and then causing the current in the heavy-holes subband to become increasingly dominant over the current in the light-holes subband, and "indirect" intrasubband transitions occurring as the radiation wavelength is further decreased and resulting in a sharp increase of the drag current. The results agree with theoretical calculations. The authors thank Ya. V. Terent'yev for assistance in the experiments. Figures 5; references 12: 10 Russian, 2 Western.

[279-2415]

UDC 621.315.592

THIRD-HARMONIC GENERATION IN n-GaAs IN CROSSED MICROWAVE ELECTRIC AND CONSTANT MAGNETIC FIELDS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 17, No 4, Apr 83  
(manuscript received 9 Nov 82, signed to press 19 Nov 82) pp 720-722

BRAZIS, R. S. and MIRONAS, A. S., Institute of Semiconductor Physics, LiSSR Academy of Sciences, Vilnius

[Abstract] The effect of a constant magnetic field which crosses a microwave electric field, on harmonic generation by free charge carriers in n-GaAs is examined, with any even weak nonlinearity of the resistive kind giving rise to odd harmonics and cyclotron resonance. In a constant magnetic field,

because the electron momentum relaxation time depends on the electron energy, the intensity of a harmonic as a function of the magnetic induction  $B_0$  has nonresonance maxima and minima. This is demonstrated theoretically for the third harmonic, on the basis of the equation of electron momentum balance in crossed fields where  $N\omega \tau_r \ll 1$  ( $N = \omega_c/\omega$ ,  $\omega_c$  - cyclotron frequency,  $\tau_r[B_0, E_0]$  - momentum relaxation time), and has been confirmed experimentally by measurement of the intensity components parallel and perpendicular to the electric field at various pumping power levels (0.3-4.3 kW). The locations of their maxima and minima along the  $B_0$  - scale depends on the amplitude of the microwave electric field. For these measurements a 100  $\mu\text{m}$  thick specimen of n-GaAs with an electron concentration  $n_0 = 3.4 \cdot 10^{14} \text{ cm}^{-3}$  and momentum relaxation time in a weak electric field  $\tau_0 = 1.6 \cdot 10^{-12} \text{ s}$  at 77 K was placed at the center of a circular waveguide 9 mm in diameter with TE<sub>11</sub>-mode pumping at 37 GHz. The results indicate that only intravalley electron scattering is responsible for generation of the third harmonic. Figures 2; references: 4 Western.  
[279-2415]

UDC 621.382.2

#### NUMERICAL SIMULATION OF TRANSIENT PROCESSES IN GaAs-DIODE STRUCTURES

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 26, No 6, Jun 83 (manuscript received 9 Nov 82) pp 93-95

VEIMRE, E. E. and FREYDIN, B. P.

[Abstract] A model for numerical simulation of transient processes in GaAs-diode structures is described, a self-consistent solution to the fundamental system of differential equations for semiconductors in the one-dimensional approximation:

$$\frac{\partial p}{\partial t} = -\frac{1}{q} \frac{\partial J_p}{\partial x} - U + G; \quad \frac{\partial n}{\partial t} = \frac{1}{q} \frac{\partial J_n}{\partial x} - U + G$$

$$J_p = -qp \mu_p \frac{\partial \psi}{\partial x} - qD_p \frac{\partial p}{\partial x} \quad J_n = -qn \mu_n \frac{\partial \psi}{\partial x} + qD_n \frac{\partial n}{\partial x}$$

$$\frac{\partial^2 \psi}{\partial x^2} = -\frac{q}{\epsilon \epsilon_0} (p - n + N) \quad J = J_p + J_n - \epsilon \epsilon_0 \frac{\partial^2 \psi}{\partial t \partial x}$$

( $U = U_{\text{non}} + U_{\text{rad}}$ ,  $U_{\text{non}}$  - rate of Shockley-Reed-Hall nonradiative recombination,  $U_{\text{rad}}$  - rate of radiative recombination,  $G$  - total rate of electron-hole pairs generation through absorption of interband recombination radiation in the various layers of the semiconductor structure). The boundary conditions for electron and hole concentrations are derived from the conditions of electro-neutrality and thermodynamic equilibrium at the contact surfaces. An additional

constraint is the relation between current through the structure and voltage across the structure according to the circuit equation for a resistive load. A steady-state distribution of all parameters is used as the initial condition. The calculation of transient processes on this basis has been programmed in FORTAN-4 on a digital computer. Calculations for a GaAs diode in series with a 0.25 ohm resistive load, allowing current densities up to  $400 \text{ A/cm}^2$  and a peak inverse voltage of 50 V, were made without and with reabsorption taken into account. The results agree within 2% for the current at any instant of time, within 7% in the d.c. mode with  $G = U_{\text{rad}}$ . Figures 2; references 5: 3 Russian, 2 Western.  
[273-2415]

UDC 621.382.2

#### NUMERICAL MODELING OF TRANSISTOR WITH CARRIER INJECTION

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 26, No 6, Jun 83 (manuscript received 21 Jun 82) pp 90-91

ABRAMOV, I. I. and MULYARCHIK, S. G.

[Abstract] Modeling a transistor with carrier injection is difficult, because the injecting p-n-p transistor usually operates at high levels even with relatively small forward bias. An important problem is to select the best initial approximation for solving the abridged fundamental system of equations,

$$\begin{aligned} -\frac{1}{q} \operatorname{div} \vec{J}_p &= R & \frac{1}{q} \operatorname{div} \vec{J}_n &= R \\ \operatorname{div} \operatorname{grad} \psi &= -\frac{q}{\epsilon} (p - n + c_N) \\ \vec{J}_p &= -q \mu_p p \operatorname{grad} \phi_p \\ \vec{J}_n &= -q \mu_n n \operatorname{grad} \phi_n \end{aligned}$$

for a transistor with one collector. A numerical solution of this system of equations by the Gummel method has been programmed in FORTRAN-LU for YeS Unified System computers. The results of calculations for such a transistor include acceptor and donor concentrations in its five regions ( $n^+$ -emitter,  $n^-$ -emitter,  $p^+$ -base,  $n^+$ -collector,  $p^+$ -injector), their vertical and horizontal dimensions, and the coordinates of their junctions. The convergence of the Gummel method in this case is somewhat slow. There also appear "numerical recombinations" and "excess charge" attributable to a high injection level  $p - c_N$  in the  $n^-$ -emitter region. Figures 1; tables 1; references 7: 2 Russian, 5 Western (1 in translation).  
[273-2415]

AVALANCHE PHOTODIODES BASED ON SOLID SOLUTIONS OF A<sup>III</sup>B<sup>V</sup> SEMICONDUCTOR COMPOUNDS (REVIEW)

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 17, No 4, Apr 83  
(manuscript received 23 Jul 81, signed to press 18 Nov 82) pp 569-582

KOROL'KOV, V. I. and MIKHAYLOVA, M. P., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Only avalanche photodiodes based on heterostructures of A<sup>III</sup>B<sup>V</sup> compounds combine high sensitivity and low noise level in a given spectral band with high-speed response (large gain-bandwidth product), which are the essential performance characteristics required of photoreceivers for optical communication systems. Compounds available for such structures in the form of solid solutions include ternary ones (InAsP, GaAlSb, GaAsSb, InGaAs) and quaternary ones (InGaAsP, GaAlAsSb, InGaAsSb). The mechanism of impact ionization and avalanche multiplication has been studied both theoretically and experimentally, the ratio of hole to electron ionization coefficients and the electron transit time in the space charge region determining the gain-bandwidth product of a device. The process of impact ionization depends largely on the energy band structure of the A<sup>III</sup>B<sup>V</sup> compounds and on the degree of anisotropy of the conduction band, especially in the case of wide energy gap, with attendant anisotropy of the ionization coefficients. Avalanche photodiodes are produced with a planar or mesa structure by various technologies, mainly by liquid-phase epitaxy but also by zinc or cadmium diffusion or by beryllium ion implantation. Further improvement of their performance characteristics is feasible, through optimization of the energy band diagram of the heterojunctions. Possibilities include matching the widths of the forbidden bands so that the gap width in one band (e.g., conduction band) is larger than the threshold ionization energy for electrons in the narrow-band material. Other possibilities are utilization of holes from a spin-orbitally detached band for impact ionization in heterostructures (InAsSb/AlGaSb), utilization of potential "jumps" for increasing the ratio of ionization coefficients in multilayer heterostructures (Al<sub>x</sub>Ga<sub>1-x</sub>As/GaAs), additional heating of charge carriers at the interface by means of a built-in isotopic p-n junction, and spatial separation of the light absorbing region in the wideband zone with a p-n homojunction. The authors thank Zh. I. Al'ferov, A. A. Rogachev, and I. N. Yassiyevich for many helpful discussions. Figures 7; tables 1; references 66: 19 Russian, 47 Western (2 in translation). [279-2415]

INDUSTRIAL ELECTRONICS AND CONTROL INSTRUMENTATION

UDC 681.3.014-681.3.06

RECURSIVE ALGORITHM FOR CALCULATING SPECTRAL POWER DENSITY IN REAL TIME

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian  
Vol 26, No 3, Mar 83 (manuscript received 1 May 82) pp 33-37

VISHNYAKOV, Yu. M., Leningrad

[Abstract] A recursive algorithm is proposed for evaluating, in real times, the spectral power density of ergodic random processes. It makes use of special fast-Fourier-transformation procedures with minimum redundant operations associated with the presence of zero elements in the input data vector. A comparison of this algorithm with the algorithm of modified periodograms in terms of machine time balance reveals that it either requires the same time for calculating operations or reduces the required time by an "acceleration" factor depending on the parameters of the computation scheme. The algorithm has been successfully tested on a process with a high-frequency (2-kHz) component, yielding a stable estimate of the spectral power density with a frequency resolution of 1.5-2 Hz. Figures 1; references 4: 3 Russian, 1 Western (in translation).

[278-2415]

## INSTRUMENTATION AND MEASUREMENTS

UDC 535.317.1

### EFFECT OF ERRORS IN POSITIONING OF LIGHT SOURCE ON ACCURACY OF PHOTOELECTRIC TRANSDUCERS WITH SCREENS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian  
Vol 26, No 3, Mar 83 (manuscript received 27 May 82) pp 11-16

MIRONENKO, A. V. and POLYARUS, N. T., Moscow Higher Technical School imeni N. E. Bauman

[Abstract] Photoelectric transducers with screens for measuring linear and angular displacements give fast and accurate readings easily put in digital form. Here a vernier coupling of the movable measuring screen and the stationary indicating screen is considered, assuming a parallel light beam, the displacement step of the vernier bands being much larger than that of the measuring screen. The error resulting from imprecise positioning of the light source is regarded and evaluated as the vector sum of two components, one perpendicular and one parallel to the optical axis of the lens. The light source, i.e., its filament, can be out of focus either toward or away from the "eye" of the optical system. The error of the readout in each case is calculated as a function of the change in distance between the two screens, with the nominal distance and the focal length of the lens as parameters. On this basis are established both lower and upper tolerance limits on defocusing of the light beam. The paper was recommended by the Department (Kafedra) of Metrology and Interchangeability. Figures 3; references 6: 5 Russian, 1 Western (in translation).

[278-2415]

UDC 621.317.3

### ERRORS OF STEPWISE APPROXIMATION IN UNIFORM DISCRETIZATION

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian  
Vol 26, No 3, Mar 83 (manuscript received 20 Oct 82) pp 3-7

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[Abstract] The greatest difference between true and approximate values of a discretized continuous signal is regarded as the maximum error and serves as a criterion for selection of the discretization frequency. Piecewise stepwise

approximation of continuous  $(n + 1)$  times differentiable signals with an  $n$ -th degree polynomial at  $(n + 1)$  successive points is considered here from this standpoint, assuming a uniform discretization step. Expressions are derived for the parameters of error distribution, namely its density and dispersion, the simplest case being an approximating polynomial of  $n = 0$  degree. The general results are applied to a harmonic signal with a  $\sin^{-1}$ -distribution of its derivative and to a random process, differentiable in the mean-square with a  $K_x(\tau) = \frac{\sin \omega_T \tau}{\omega_T}$  correlation function, as well as to a non-differentiable random process with a  $K_x(\tau) = e^{-\alpha |\tau|}$  correlation function. The approximation error characteristics for signals with various other typical correlation functions are tabulated. The paper was recommended by the Department (Kafedra) of Information-Measuring Technics. Figures 2; tables 1; references: 4 Russian.  
[278-2415]

UDC 621.317.023

#### SYNCHRONIZATION OF BEGINNING OF MEASUREMENT BY DIGITAL PHASE METERS WITH CONSTANT MEASURING TIME

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian  
Vol 26, No 3, Mar 83 (manuscript received 22 Apr 82) pp 20-26

POKHILYUK, A. P., Vinnitsa Polytechnical Institute

[Abstract] The low-frequency error of time-to-pulse converters in digital phase meters with constant measuring time is analyzed, the error which occurs during synchronization of the beginning of measurement. The statistical characteristics of this error are calculated by the spectral method, which readily yields all the required relations in the form of Fourier series. These relations include dependence of the error on the fractional part of the ratio of measurement time to signal period and on the phase shift of the beginning of measurement. Calculations are made for a single-channel converter and a multichannel one. The results indicate that synchronization of the beginning of measurement produces a systematic error component, which vanishes with a zero mathematical expectation at a certain magnitude of the phase shift. With an optimum  $N$ -channel converter, channels starting with successive  $2\pi/N$  phase shifts, all parameters of the low-frequency error are reduced by a factor of  $N^2$ . The paper was recommended by the Department (Kafedra) of the Theoretical Bases of Radio Engineering. Figures 4; references: 8 Russian.  
[278-2415]

UDC 681.7.067.223.2

DISPERSIVE CHARACTERISTICS OF GLASSES AND SYNTHESIS OF  
APOCHROMATIC SYSTEMS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 3, Mar 83 (manuscript received 18 Mar 82) pp 84-89

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[Abstract] The dispersive characteristics of glasses are analyzed from the standpoint of producing an apochromatic set of three lenses whose power does not exceed an a priori stipulated level. The constraints on the scale, on the correction of positional chromatism, and on the secondary spectrum are written in the form of three linear algebraic equations, each the sum of three terms (one for each lens) equal to unity, to zero, and to zero respectively, in the two-dimensional system of rectangular coordinates  $x, y$  ( $x = 1/v$ ,  $y = \gamma/v$ ,  $v$ -dispersion coefficients,  $\gamma$ -relative partial dispersions). A simultaneous solution of these equations yields the power of each lens in the form of determinants, a different one in the numerator for each lens and the same one in the denominator for each lens, all determinants appearing as triangles in the  $(x, y)$ -plane. A glass for each lens is defined by a point in this  $(x, y)$ -plane, point C (glass of the third lens) lying either to the left or to the right of the straight line joining points A and B (glasses of the first two lenses). The locus of points C is a straight line through the origin of coordinates. Mapping into the  $(v, \gamma)$ -plane yields the region of special glasses satisfying simultaneously the two conditions for apochromatism with respect to powers of the lenses. Numerical data in this context are given for five combinations of three glasses, one for each lens, from seven available grades (TF10, LK3, STF2, OK1, OF6,  $\text{CaF}_2$ ,  $\text{BaF}_2$ ). The paper was

recommended by the Department (Kafedra) of the Theory of Optical Devices.

Figures 4; tables 2; references 7: 4 Russian, 3 Western.

[278-2415]

UDC 621.311.53.087.92

ANALOG ANGLE AND FREQUENCY TRANSDUCERS BUILT WITH INTEGRATED MICRO CIRCUITS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 83 pp 58-61

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[Abstract] Two analog transducers have been designed with a K140UD8A operational amplifier as the basic building block. The angle transducer measures the electrical angle between two voltage vectors or (with the aid of other appropriate devices) the angle between generator emf and output voltage. It consists of two input signal transformers which decouple the input voltages and step them down to microcircuit level, a  $0-180^\circ$  phase shifter, two amplifiers which also shape rectangular bipolar voltage pulses, a trigger which generates rectangular pulses of duration proportional to the phase shift

between the output voltages of those two amplifiers, a pulse duration-to-amplitude converter which generates a voltage of amplitude proportional to the duration of the trigger output pulse, a sampling-storing device which generates an analog signal proportional to the phase shift between the output voltages of those two amplifiers, and a power amplifier which raises the load capacity of the device. This angle transducer has a 0-360° range, operates with input signals of 5-100 V and 50 Hz, delivers output signals of 0-10 V with a load capacity of 100 mA and a time delay of 0.02 s. The frequency transducer consists of an input transformer which steps down a periodic voltage and then converts it to rectangular pulses of amplitude and repetition rate depending on the amplitude of the input voltage, a pulse duration-to-amplitude converter which generates a voltage of amplitude precisely proportional to the period of the input voltage, a sampling-storing device, and a power amplifier which matches the output to a low-impedance load and compensates the output signal, if necessary, by generating a signal proportional to the slip. This frequency transducer has a 30-55 Hz range, operates with input signals of 5-100 V, delivers output signals of 0-10 V with a load capacity of 100 mA and a time delay of 0.02 s. The minimum saturation voltage for the K140UD8A operational amplifiers (in each amplifier-shaper and phase shifter, input transformer-shaper, duration-to-amplitude converter, sampling-storing, and power amplifier stages) is 2 mV, which determines the transducer sensitivity. An input voltage of 5 V is the reliability threshold. Figures 4; tables 2; references:  
4 Russian.  
[286-2415]

MICROWAVE THEORY AND TECHNIQUES

UDC 621.396.677

GENERALIZED PERFORMANCE CHARACTERISTICS OF MICROWAVE DEVICES

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 26, No 6, Jun 83 (manuscript received, after revision 9 Dec 82) pp 37-41

MAKSIMOV, V. M.

[Abstract] Performance and design characteristics of microwave devices are generalized in terms of three matrices, namely the scattering matrix and two immitance (impedance and admittance) matrices. The relations between input and output quantities, voltage-current relations, as well as for energy of the electric field and of the magnetic field, are defined for a reciprocal device according to the Lorentz lemma and for a lossless device according to the Poynting theorem. This formulation reveals that the mathematical properties of the output characteristic depend not only on the physical properties of the device but also on the choice of coefficients normalizing the eigenfunctions as well as the equivalent input voltages and currents. Figures 1; references 6: 5 Russian, 1 Western (in translation).  
[273-2415]

UDC 681.325.5

USE OF MICROPROCESSOR SYSTEM IN DIALOG MODE FOR AMPLIFIER DESIGN

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 26, No 6, Jun 83 (manuscript received 28 May 82) pp 75-77

ZLATAROB, Vasil K., IVANOV, RACHO M., MIKHOV, GEORGI S.,  
NEDELCHEV, NEDYALKO, M., and DINOV, RANGEL, V., Higher Institute of Electrical  
Engineering imeni Lenin, Sofia [Bulgaria]

[Abstract] A microprocessor system including an input/output module and two memories has been developed and built at the Higher Institute of Electrical Engineering imeni Lenin in Sofia [Bulgaria] for microcomputer-aided design, in the dialog mode, of amplifiers. Its read-only memory and main memory are functionally separated, the latter or a part of it being also addressable for service operations as an aid to the user. The system operates in BASIC, the algorithms being stored in 7 kbytes of the main memory. The output data can be displayed on the screen of a commercial television set or of a special-purpose television monitor. The designer's functions are selecting the type

of amplifier circuit (e.g., common-emitter) and specifying some of the essential performance parameters. The microprocessor calculates all necessary performance characteristics and optimizes the design to match the specifications. This system has already been used for designing amplifier stages with 2T3167A/B and 2T3168A/B/C silicon transistors. Figures 2; references 4:  
2 Russian, 2 Western (both in translation).  
[273-2415]

UDC 621.311.21:621.221.3.003.1

ADDITIONAL EFFECT OF ENERGY STORAGE AS RESULT OF ECONOMY OF SCARCE AND EXPENSIVE FUELS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 83 pp 4-6

YERSHEVICH, V. V., candidate of technical sciences, and KIR'YANOVA, N. A., engineer, All-Union State Planning, Surveying and Scientific Research Institute of Power Systems and Electric Power Networks (Energosetproyekt)

[Abstract] Possible sites of large-scale energy storage are hydro-storage electric power plants, air-storage gas-turbine electric power plants, heat-storage tanks in atomic electric power plants, and electric power plants with inductive, capacitive, or chemical storage devices. The purpose of energy storage is threefold: 1) covering peak or semipeak loads; 2) increasing the transmission capacity of networks; 3) conversion of energy from one form used for charge to another form used for discharge. At the present time only hydro-storage electric power plants are the only type fully equipped and available for large-scale energy storage during low-demand periods, coverage of peak or semipeak loads during high-demand periods being the primary purpose. An additional effect of energy storage is analyzed and evaluated here, namely the effect of using most abundant and least expensive fuels and of replacing with them least abundant and most expensive ones for discharge in an energy conversion process when the variable load curve does not have to be smoothed. The quantitative analysis is also extended to the additional effect of energy storage as a result of "fuel conversion." Calculations are based on data on fuel consumption rates  $g/(kW \cdot h)$  and fuel costs (rub/t) taken from two hydro-storage electric power plants (Zagorsk and Kayshyadoris) and are made for the Joint Northern and Western Power System, specifically referring to additional utilization of a 1600 MW hydro-storage electric power plant normally used for covering peak loads for 500-1000 hours in a year. The results indicate that these additional effect contribute appreciably to the overall technical and economic indicators of large-scale energy storage equipment. Figures 1. [286-2415]

UDC 621.311-52.001.2<sup>4</sup>

DESIGN OF SYSTEM FOR GATHERING TELEMETRIC DATA

Moscow ELEKTRICHESTVO in Russian No 5, May 83 (manuscript received 19 Apr 82)  
pp 48-49

BOGDANOV, V. A., Moscow

[Abstract] Criteria and algorithms have been developed for the design of a telemetric data gathering and transmission system in an electric power system. Here the theoretical approach is applied to a practical example. The procedure includes determining the number and the information content of measured parameters, determining the most expedient locations of measurement points, selecting the cycles of repeated telemetering, selecting the circuit and the structure of the telemetering system, and determining the lengths of communication channels with transmission capacity as well as cost and reliability taken into account. In the specific example an electric power distribution system consists of 45 nodal points interconnected by a 110 kV - 50 MW overhead network (36 lines) and a 220 kV - 200 MW internal overhead network (15 lines) with a 250 MW tie (2 lines) to a neighboring system. For organization of measurements and data collection, the system is reduced to a simpler equivalent one where less significant nodal points have been replaced with equivalent loads and sources not requiring measurement. Instrumentation and connecting lines are selected according to those given criteria. Several variants of the telemetering system are evaluated comparatively for optimum choice. Figures 1; tables 1; references: 1 Russian.

[285-2415]

UDC 621.311.076.12.026.5.001.5

TRENDS OF RESEARCH ON COMPENSATION OF REACTIVE POWER

(Discussion of article by ZHELEZKO, Yu. S. in ELEKTRICHESTVO No 10, Oct 81)  
Moscow ELEKTRICHESTVO in Russian No 5, May 83 pp 58-72

MOLODTSOV, V. S., candidate of technical sciences

[Abstract] The article by Yu. S. Zhelezko dealt with trends in research on compensation of reactive loads in 35-kV electric power systems. Discussion by V. S. Molodtsov (candidate of technical sciences). The author has not formulated the problem of compensation and has not stated the reasons for compensation, and then not solved the problem of research stages quite correctly. The discusser is concerned specifically with the system structure and the interrelation of errors. Basic trends in this area are stated and conclusions are drawn from an analysis of optimal system design. References: 3 Russian. Discussion by V. G. Zhuravlev (doctor of technical sciences) and V. D. Arion (candidate of technical sciences). The author has shifted the focus from "determining the optimum state of the model" to "practical implementation of the results of model calculations in the actual object

(compensator of reactive loads)". The discussers point out how important it is, however, to organize all calculations pertaining to the target function in the mathematical model first. The discussers agree with the author's emphasis on a compensation strategy on a year-by-year basis. Discussion by A. A. Tayts (doctor of technical sciences) and Ye. N. Prikonskiy (engineer). The four problems most deserving of consideration in further research are: validation of a deterministic network model based on the fifth year of a Five-Year system development, establishment of broad planned economic targets for compensation of reactive loads beyond merely the requirements under operating conditions, and defining the distinctions between principles of total cost minimization and principles of determining the cost effectiveness of individual compensators, validation of estimates based on cost of energy losses in the network. References: 4 Russian. Discussion by A. M. Kerimov (doctor of technical sciences) and Ye. B. Gurfinkel' (candidate of technical sciences). The author has not emphasized the fact that methods of solving the compensation problem differ depending on the objective. The discussers propose another approach to "construction of a mathematical model of the optimized object", namely on the basis of estimates and classification of reactive-power sources and users, with inclusion of these sources during the planned Five-Year development period and subsequent annual refinement or correction. The optimization problem ought to be solved with complexity at various hierarchical levels according to the classification. Discussion by I. Ya. Tarikuliyyev (candidate of technical sciences). The discusser agrees with the author on the deficiencies of capacitor banks, but suggests that the results of cost effectiveness analysis justify a higher degree of compensation. References: 5 Russian. Discussion by O. S. Mamedyarov (candidate of technical sciences). The discusser agrees with the author on the multicriteriality of the compensation problem and further refines the optimization problem, by taking into consideration compatible spacing of regulators and compensators as well as smoothing the effect of imprecision of input data. It is pointed out that, except in the case of the optimum variant being better than all others in every respect, choosing among alternatives can be very difficult. A program of multicriterial calculations is being developed at the Azerbaijan Scientific Research Institute of Power Engineering. References: 3 Russian. Discussion by M. M. Parkhadanov. The discusser contributes the formulation of a deterministic model and of a stochastic model for optimum compensation of reactive power, considering only the mathematical expectation of the economic risk along with the Savidge criterion and the Hurwitz criterion as most relevant here, whereupon he deals with two selection problems: selecting the set of initial variants of the total load and selecting competitive variants of total power of reactive power sources. Reply by Yu. S. Zhelezko (author). The author responds to criticism by these and other discussers, explains his position on the issues raised by them, and justifies his approach. He also briefly discusses the problems of including constant cost components in the evaluation of compensators, the methods of decomposition and equivalent replacements in system design analysis, and methods of selecting compensator sizes (power ratings) and locations. He leaves room for further discussion and points out the difficulties in treating some aspects of certain problems. The editorial staff of ELEKTRICHESTVO agrees with the practical approach taken by the author, in view of the importance of fuel and energy conservation.

[285-2415]

UDC [621.311.22+621.311.25:621.039]:614.841.4

BASIC PROBLEMS OF FIRE PROTECTION IN ELECTRIC POWER PLANTS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 83 pp 7-11

TODRES, Yu. V., engineer, All-Union Planning, Surveying and Scientific Research Institute of Hydraulic Equipment (Gidroproyekt)

[Abstract] Fire protection must meet more severe requirements in atomic electric power plants than in conventional such as thermal electric ones. Water is still the principal extinguishing agent, owing to its abundant availability and easy transportability, low cost, chemical neutrality and nontoxicity. Water pressure and flow rate are, therefore, the basic parameters determining the design of a fire extinguishing system. Generally a water jet is used against fire outside and water mist is sprayed against fire inside equipment. Electrical equipment most vulnerable under short circuits and most susceptible to fire are power cables and transformers, both containing solid insulation and oil. The design of protection against fire, after an analysis of its causes and of its modes of spreading, involves smoke detection, minimization of response delay, remote automatic control, optimum selection and utilization of active extinguishing equipment (jet nozzles, spray nozzles, pumps, startup and shutoff devices), and reliability assurance. In atomic and thermal electric power plants a water jet is recommended against fire outside and inside buildings as well as for cooling the roof trusses of machine rooms. Water mist is recommended against fire in large transformers and reactors as well as in feedthrough cable equipment and for cooling large cooling-oil tanks. Tables 2; references: 10 Russian.

[286-2415]

UDC 621.311.22:658.003.1

METHODS OF ORGANIZING INTRAPLANT ECONOMIC DESIGN IN ELECTRIC POWER PLANTS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 83 pp 2-4

VARIVODA, A. A., engineer, and PADALKO, L. P., candidate of technical sciences, Belorussian Main Power System Administration and Belorussian Polytechnic Institute

[Abstract] In a thermal electric power plant each component is not an independent economic unit but does directly affect the overall plant performance indicators, all components being interlinked through a continuous fast technological process which precludes stall and accumulation of the intermediate product anywhere along the line. Planning and design are aimed primarily at an improvement of the reliability and the fuel economy, quantifiable in terms of the availability factor and the fuel consumption rate respectively. A set of criteria has been established accordingly for the various departments of a typical thermal electric power plant in Belorussia:

fuel transportation, boiler-turbine set, electric power generation, chemical treatment, measurements and automation in thermal system, and central repair shop. Performance indicators have been defined and calculated for each, including characteristic modes of failure and resulting penalties. Calculations include cost of labor and material as well as investment costs. Economic planning and design organized on the basis of such an approach for the Belorussian Power System in 1978 and applied to two thermal electric power plants in Minsk for 1982 has resulted in an improvement of the fuel economy over the previous year by 4.5 g/(kW·h) in the TETs-3 plant and 4.9 g/(kW·h) in the TETs-4 plant. Tables 2.

[286-2415]

UDC 621.314.224.027.81/.88

#### ADDITIONAL ERRORS OF 750 kV CURRENT TRANSFORMERS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 83 pp 67-68

DANILOVICH, M. S., engineer, and SPRYSA, V. V., engineer, Southern Power System Engineering Administration (Yuzhtekhnenergo)

[Abstract] TRN-750 (IRFM 750 A) current transformations for 750 kV power systems consist of an upper 2000-4000/20 stage and a lower 20/1 stage. The capacitive current component preferentially flows through the primary winding of the low-impedance lower stage, but there also flows a capacitive current through the secondary winding of the upper stage. Capacitive current contributes to both angle and ratio errors, the additional angle error being maximum when active current flows in the primary and reducing to almost zero, while the additional ratio error becomes maximum, when reactive current flows in the primary. The capacitive current component in the secondaries causes the transformer errors to exceed allowable levels according to Government Standard specifications for instrument transformers of Class 0.2 accuracy, while hardly affecting the operation of protective relays and automatic controls. This is detected in the field under operating voltage but not in the factory, where current transformers are tested for error without application of 750/ /3 kV. With the interstage coupling coils properly connected to the terminal board, the capacitive current across insulation will not flow through these coils.

Figures 2.

[286-2415]

UDC 621.315.052.001.2

SINGLE-PHASE AUTOMATIC RECLOSE IN TWO-CIRCUIT INCREASED-CAPACITY OVERHEAD POWER TRANSMISSION LINES

Moscow IZVESTIYA AKADEMII NAUK SSSR: ENERGETIKA I TRANSPORT in Russian No 3, May-Jun 83 (manuscript received 17 Dec 81, after revision 6 May 82) pp 91-100

KADOMSKAYA, K. P., KANTSLER, P. V., LEVINSHTEYN, M. L. and TSEDZHINOV, Ye. S., Novosibirsk

[Abstract] Protection and reliability of composite overhead a.c. power transmission lines with strong electromagnetic coupling is considered in the typical case with the high-voltage three-phase conductors running above the low-voltage three-phase conductors. Single-phase short-circuit in either the high-voltage line or in the low-voltage line is the most common type of fault. Single-phase automatic reclose without or with automatic shunting at both ends is evaluated as a method of clearing such faults, the main problems being first to ensure self-quenching of the makeup arc within a time sufficiently short for retention of dynamic stability in the system and then to limit overvoltages during the recovery process. Calculations are shown for three arrangements of the two three-phase lines on transmission poles: 1) each on a separate metal crossbeam; 2) h-v conductors on metal crossarm and l-v conductors on concrete columns below; 3) h-v conductors suspended with guys and l-v conductors supported on concrete columns. Assuming typical values for resistances, inductances and capacitances per unit length, peak transient currents in each circuit during a fault and a reclosure are calculated for ideally spaced and nontransposed conductors as well as for a single cycle. Calculations also include conditions during the zero-current pause in the reclosing cycle and the distribution of switching overvoltages. The results serve as a basis for the design of arc control devices and overvoltage limiters in a system with single-phase automatic reclosing in both high-voltage and low-voltage circuits. Figures 6; tables 5; references: 10 Russian.

[281-2415]

UDC 621.315.1.027.8.004(-17)

OPERATING EXPERIENCE WITH 110 AND 220 kV OVERHEAD TRANSMISSION LINES IN FAR NORTHERN REGIONS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 3, Mar 83 pp 56-59

D'YAKOV, A. F., engineer, and KUZNETSOV, V. A., engineer, Main Eastern Power System Administration and Krasnoyarsk Power System

[Abstract] Data are reported on the operation of existing 110 and 220 kV overhead transmission lines in the southern part of the Taymyr peninsula, where the winter is severe and the weather is unstable in all seasons with the average temperature in a year  $-9.6^{\circ}\text{C}$  and the lowest temperature  $-64^{\circ}\text{C}$ . These data reveal two basic types of damage, both associated with formations ranging from hard ice to wet snow and including mixtures of each. Damage of

the first type occurs in the form of a massive fracture of wooden poles and rupture of conductors under ice-snow layers of 0.3-0.9 g/cm<sup>3</sup> density which build up within a few hours at wind velocities of 2-20 m/s and temperature from 0 to -10°C. Damage of the second type occurs in the form of vibration and "dancing" of conductors, with subsequent bending of insulator pins hail grains 50-120 mm in diameter and of 0.2-0.4 g/cm<sup>3</sup> density at temperatures down to -33°C, associated with heat and moisture release from natural and industrial local sources (water storage pools for hydroelectric power plants, nonfreezing basins, hot tailings from thermal electric power plants and from metallurgical manufacturing plants). A correct evaluation of these data for purposes of planning and design must take into account microclimate characteristics, especially in the mountainous part of the region and near water storage pools. On the basis of such an evaluation, aided by more precise reporting and analysis by the meteorological service, it should be possible to update the overhead transmission system here for both present and growing demand. Figures 5; tables 2; references: 3 Russian.  
[283-2415]

UDC 621.316.1.018.782.3.001.24

#### CALCULATION OF TRANSIENTS IN ELECTRIC POWER SUPPLY SYSTEM WITH ABRUPTLY CHANGING LOADS

Moscow ELEKTRICHESTVO in Russian No 5, May 83 (manuscript received 22 Sep 82)  
pp 1-4

ARZAMASTSEV, D. A., IGUMENSHCHEV, V. A., SALAMATOV, I. A. and KOVALENKO, Yu. P., Sverdlovsk-Magnitogorsk

[Abstract] The method of successive equivalent replacements is proposed for calculation of transients in large electric power supply systems with abruptly changing and impact loads. The method combines simplicity with efficiency and takes into account long-duration transients in multimachine systems with high dimensionality and large diversity. The method has been used successfully for optimizing the distribution of reactive power in a network. The calculated power flux distribution before a transient serves as the initial condition. An elementary building-block circuit can be extracted from any interconnected and hierarchically structured system. A circuit consisting of a power source (generator, synchronous motor) or a load. First the load is replaced with an equivalent admittance; subsequent replacements are equivalent circuits with successively one less variable (power flux in synchronous machines). The differential equations describing electromechanical and electromagnetic processes in the last equivalent circuit are integrated numerically by the method of successive intervals. At the end of each time interval of the transient period each synchronous machine is represented by its synchronous and asynchronous electromagnetic power, mechanical power at the shaft, emf, active and reactive power delivered to the network or to users directly, power angle and its rate of change. The electrical loads presented by manufacturing equipment which operates in the abrupt-change or impact mode

are described by oscillograms of active and reactive power recorded and characterizing the technological cycle. The algorithm of calculations on the basis of a complete mathematical model has been incorporated in the NESTA program for a YeS 1020 Unified System digital computer. This program was used for engineering calculations of transients in the power supply system in the Magnitorsk Metallurgical Combine. The results confirm the need for switching the main drives of press tools to the underground substation as power source. Figures 6; references: 5 Russian.

[285-2415]

UDC 621.316.542.027.3.064.001.5

#### SWITCHING CAPACITY OF HIGH-VOLTAGE CIRCUIT BREAKERS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 3, Mar 83 pp 40-44

ZHMURKO, V. A., engineer, DOVAL', A. Yu., engineer, MITSAY, A. D., engineer, and ROGOZIN, G. G., candidate of technical sciences, Donbass Power System and Donetsk Polytechnic Institute

[Abstract] A program of calculations pertaining to transient processes in large high-voltage power systems has been developed jointly by the Donbass Power System and the Donetsk Polytechnic Institute, for evaluation of the required switching capacity and reliability of circuit breakers. These calculations take into account electromagnetic and electromechanical effects during symmetric and asymmetric, single-phase and three-phase, short circuits in a complex power system. The model of such a system includes not only synchronous machines and circuit breakers but also current limiting devices, transient processes being simulated by the method of symmetric components. After the corresponding system of differential equations has been converted to an algebraic one, the algorithm yields node voltages and branch currents, related through the dynamic-impedance matrix, in each time interval of the transient period. Calculations have been made for three regional hydroelectric power plants (Uglegorsk 330 kV, Starobeshev 220 kV, Voroshilovgrad 220 kV) with installed turbogenerators ranging in size from 25 to 800 MW. On the basis of the results of such calculations, it is possible to design rationally and select circuit breakers with auxiliaries in accordance with Government Standard 687-78 specifications. Figures 3; tables 1; references: 9 Russian.

[285-2415]

UDC 621.372.061

#### STABILIZING CHARACTERISTICS OF PARAMETRIC CURRENT SOURCES

Moscow ELEKTRICHESTVO in Russian No 5, May 83 (manuscript received 13 Aug 81) pp 25-29

VADACHKORIYA, G. V., candidate of technical sciences, Georgian Polytechnic Institute

[Abstract] The stabilizing characteristics of parametric current sources, theoretically supplying constant current to a varying load, are analyzed on

the basis of the equivalent-voltage-generator theorem and an equivalent circuit of a current generator. In this equivalent circuit three sources with common ground feed a T-load through its three terminals. Any fixed operating mode, except no load, can serve as reference. The corresponding equations are formulated so as to include deviations of the load parameters from nominal values in terms of three coefficients  $k_L = L/L_0$ ,  $k_C = C/C_0$ ,

$k_\omega = \omega/\omega_0$  ( $L_0, C_0, \omega_0$  - nominal inductance, capacitance and frequency). From these equations are determined the sensitivity of the load current to the various load changes and the stability limits. The general results of this analysis are applied to a specific T-load with a pure inductance in the center branch, a pure capacitance in one arm, and a resistive-capacitive or resistive-inductive impedance in the other arm. Using the minimum total reactive power normalized to the active load powers as the optimality criterion, one can achieve this condition and thus maximize the stability only by adjusting the nominal load normalized to the nominal Q-factor to its critical value corresponding to this optimum. Numerical data are shown to demonstrate this. Figures 6; tables 4; references: 9 Russian.

[285-2415]

UDC 621.374(07)(049.3)

FIELDS AND TRANSIENT PROCESSES IN SUPERHIGH-CURRENT EQUIPMENT: REVIEW OF BOOK  
BY G. A. SHNEYERSON (LENINGRAD, ENERGOIZDAT, 1981)

Moscow ELEKTRICHESTVO in Russian No 5, May 83 p 74

BONDALETOV, V. N., doctor of technical sciences, and VOLKOV, N. B., candidate of technical sciences

[Abstract] The book FIELDS AND TRANSIENT PROCESSES IN SUPERHIGH-CURRENT EQUIPMENT by G. A. Shneyerson has five chapters. The first Chapter deals with fields of long conductors with strong skin and edge effects. It includes inductance and electric field calculations for conductors in various configurations. The second chapter and the third chapter deal with various methods of magnetic field calculations for solenoids in typical configurations, with the third chapter containing extensive reference material. The fourth chapter deals with processes accompanying penetration of magnetic fields into conductors, including the transient skin effect. It presents solutions to problems of plane and cylindrical magnetic shields. The fifth chapter outlines the theory of transient processes in inductive and capacitive energy storing devices with heavy conductors and with nonlinear as well as linear elements. The book is interesting from the methodical standpoint, but is deficient in its treatment of the current distribution in plane capacitors and of pulsing magnetic fields produced by magnetic or magnetodynamic methods. These deficiencies are attributable to a lack of space rather than the author's negligence, inasmuch as he covered these problems elsewhere.

[285-2415]

QUANTUM ELECTRONICS/ELECTRO-OPTICS

UDC 621.378.336

STATISTICAL APPROXIMATION OF STATIC CURRENT-VOLTAGE CHARACTERISTICS OF GAS LASERS

Kiev TEKHNICHESKAYA ELEKTRODINAMIKA in Russian No 3, May-Jun 83  
(manuscript received 26 Feb 82) pp 40-46

VOLKOV, V. L. and ZAKREVSKIY, S. I.

[Abstract] The problem of obtaining an equation for the static current-voltage characteristics of a gas-discharge arc, an equation which covers most accurately the entire range of operating currents and as many different gas-discharge devices as possible, is treated by the method of a planned experiment and statistical approximation. With the Ayrton equation used as a priori information, a full  $2^2$ -factorial experiment yields an approximation of the same form as the corresponding regression equation  $Y = b_0 + b_1 x_1 + b_2 x_2 + b_{12} x_1 x_2$  ( $x_1, x_2$  - coded values of the two independent variables  $X_1, X_2$ ). The two independent variables are the current  $I$  and either the gap length  $L$  (gas pressure  $P = \text{const}$ ) or the gas pressure  $P$  (gap length  $L = \text{const}$ ). The target function  $Y$  is voltage  $V$ . On the basis of available experimental data on a tube containing a helium-neon mixture between two electrodes, the approximating equation for the static current-voltage characteristic of such a device becomes  $V = 154 + 45.6L + 11.2(\ln I) - 4.78(\ln I)$  ( $P = \text{const}$ ) or  $V = 2655 + 300P - 125(\ln I) - 36P(\ln I)$  ( $L = \text{const}$ ) within 2.5-3% accuracy. A similar evaluation of data on various gas lasers (He-Ne,  $\text{CO}_2$ , He-Se vapor) yields for these devices approximating current-voltage equations of the same form. Figures 4; tables 4; references: 6 Russian.

[282-2415]

SOLID STATE CIRCUITS

UDC 621.3.049.771.14.001.57

MODELING COMPONENTS OF SOLID-STATE INTEGRATED CIRCUITS BY ALGORITHMS OF  
SUCCESSIVE TRANSFORMATIONS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIODELEKTRONIKA in Russian  
Vol 26, No 6, Jun 83 (manuscript received 30 Nov 82) pp 52-58

YASHIN, A. A.

[Abstract] Full-scale modeling of fabrication processes in the development of a monolithic IC technology is necessitated by three factors: 1) the size of components is decreasing drastically; 2) Microelectronic devices are still produced essentially by the hybrid technology; 3) Design procedures are being increasingly automated and their accuracy must also increase. The object of modeling a process is to control it so that it will yield components with the required characteristics. Physical modeling of integrated structures is based on simulating the solution to Fick equations for diffused bipolar devices or field-effect equations for MOS devices. The principle is demonstrated on a planar transistor, but it applies to most other transistor and diode structures as well as to diffused resistors and capacitors. The procedure involves delineating individual two-dimensional regions for estimation of distributed useful parameters and parasitic parameters. This is best done by the method of conformal mapping with an algorithm of successive transformations. This is often the only method feasible, it is most expedient where the solution of Dirichlet, Neumann, or other boundary-value problems is involved, and in some cases it can be combined with application of the Maxwell similarity principle or the Bartlett symmetry theorem. For modeling IC components for computer-aided automatic design, after the IC structure has been subdivided according to the decomposition principle, the most effective two conformal mapping algorithms are "successive Re-contractions" and "quasi-canonicalization with  $R_{var}$ -circle" with appropriately selected mapping segments and steps. Figure 2; references 21: 16 Russian, 5 Western (2 in translation).

[273-2415]

SONICS AND ULTRASONICS

UDC 621.391:621.313.322

USE OF STATISTICAL SPECTRAL-CORRELATIONAL ANALYSIS FOR VIBROACOUSTICAL  
DIAGNOSIS OF ROLLER BEARINGS IN ELECTRICAL MACHINES

Kiev TEKHNICHESKAYA ELEKTRODINAMIKA in Russian No 3, May-Jun 83  
(manuscript received 6 Nov 81) pp 58-64

MYSLOVICH, M. V. and OSADCHIY, Ye. P.

[Abstract] Statistical spectral-correlational analysis is considered for diagnosing the state of roller bearings in electrical machines during operation on the basis of vibroacoustic noise. For an experimental evaluation were used 309 YeSh<sub>2</sub> bearings in a d.c. machine, a set of 4367 accelerometers (transducers) with a 2626 preamplifier, a Brüel & Kjaer 7003 instrument magnophone, and an M-222 computer for processing recorded analog signals after their conversion to digital ones. There are two known methods of such a statistical analysis, one is calculation of the energy spectrum through direct use of the fast Fourier transformation with subsequent averaging and the other is expressing the energy spectrum through the Fourier transform of the autocorrelation function with use of weight functions (windows) for smoothing. In this study the second method was tried, with a Bartlett window, a rectangular window being unsuitable here because of large fringes in the frequency domain and, consequently, a too large dispersion. Numerical data were processed according to the procedures of spectral analysis and correlational analysis, both programmed in ALGOL-60 for a TA-2M translator. The analysis has been found to reveal bearing misalignment. The results confirm that correct diagnosis of bearings requires not only spectrograms covering a frequency range as wide as 0-40 kHz but also high-speed processing of primary vibroacoustic data. The method is applicable to detection of fatigue defects as well as excessive wear with lubricant or following depletion of the lubricant. Figures 4; references 10: 5 Russian, 5 Western (2 in translation).

[282-2415]

NEW ACTIVITIES, MISCELLANEOUS

UDC 771.351.4:778.6]:778.681

SELECTION OF DYE TRIAD FOR POSITIVE MOTION-PICTURE PHOTOGRAPHIC FILM ON BASIS OF COLOR REPRODUCTION REQUIREMENT

Moscow TEKHNIKA KINO I TELEVIDENIYA in Russian No 6, Jun 83 pp 10-16

ZERNOV, V. A., MALEYEV, A. M., NABOKOV, O. A. and BONGARD, S. A., All-Union Scientific-Research and Design Institute of the Chemico-Photographic Industry and All-Union Scientific-Research Institute of Cinematography

[Abstract] Dye triads for photographic films are selected on the basis of their ability to reproduce colors of typical objects. A selection of yellow-purple-blue triads was made of positive photographic films on the basis of their color gamuts, color separation and gray-scale reproduction characteristics, the latter including the stability of the gray field to changes in the spectral composition of the illuminating light and the proportionality of the visual response intensity to the surface concentration of the dyes. Calculations were made by cutting vertically and horizontally through the  $U^*V^*W^*$  chromaticity diagram and determining the colorimetric parameters. Two positive motion-picture photographic films (TsP-11 and Kodak 5383) and two other triads (TsP-12 with maximum absorption by yellow dye shifted from 430 to 440 nm and a mixture of natural dyes with maximum absorption by yellow and blue dyes at wavelengths farthest from that of maximum absorption by purple dye) were compared with one another and with a triad of ideal dyes. In this way was established a set of criteria, rather than a single criterion, for optimum choice of dye triad. According to the results of this evaluation, the TsP-12 triad with maximum light absorption by the dyes at 440, 540, 660 nm wavelengths respectively would be optimum for matching the colorimetric characteristics of objects and their positive images. Figures 6; tables 4; references 16:

8 Russian, 8 Western.

[269-2415]

UDC 621.311

OPTIMUM POWER DISTRIBUTION IN SUPERCONDUCTING CABLE SYSTEMS

Moscow IZVESTIYA AKADEMII NAUK SSSR: ENERGETIKA I TRANSPORT in Russian No 3, May-Jun 83 (manuscript received 1 Feb 82) pp 57-65

YAKIMETS, I. V., SAVEL'YEV, A. Ya. and BLINKOV, Ye. L., Moscow

[Abstract] An important problem in the design of superconducting cable systems for operation in parallel with existing conventional high-voltage overhead lines is optimization of the power distribution. A hybrid superconducting-conventional power transmission system is characterized by a high degree of nonhomogeneity, especially when segments of conventional transmission lines are coupled through transformers. The optimum power distribution resulting in minimum power losses is determined by considering that the power in parallel cables is inversely proportional to their impedances and that the reactance of superconducting cables is one order of magnitude lower than that of conventional overhead lines. The power losses in each are calculated on this basis, whereupon the natural power distribution and the economical power distribution are established, the latter taking into account characteristics of cryogenic cooling equipment and the particular power-temperature relation. Numerical data on conventional 220, 330, 500, 750, 1150 kV overhead lines and on superconducting ( $Nb_3Sn$ ) 110, 220 kV cable for 0.122-5.3 GW and 0.92-3.75 GW power systems respectively provide a basis for designing the optimum power distribution. While economical power transmission by a superconducting cable system operating below its optimum capacity is also the optimum power distribution at the given load level and while economical power transmission by a superconducting cable system can be achieved under conditions approaching those for transmission of real power, in most hybrid superconducting-conventional systems the natural power distribution is not the economical one and its optimization to make it so requires direct-axis compensation or transformers with direct-quadrature regulation for producing a quadrature emf equal to 30-60% nominal voltage. Figures 5; tables 2; references: 5 Russian.  
[281-2415]

UDC 778.534.83

OPTICAL SYSTEMS FOR HIGH-SPEED PHOTOGRAPHIC CAMERAS WITH OPTICO-MECHANICAL SWITCHING

Moscow ZHURNAL NAUCHNOY I PRIKLADNOY FOTOGRAFII I KINEMATOGRAFII in Russian Vol 28, No 3, May-Jun 83 (manuscript received 27 Nov 81) pp 198-204

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[Abstract] Existing optical systems for high-speed photographic cameras with optico-mechanical switching can be classified into those with one intermediate image and those with two intermediate images. For improving the image

quality in a system of the first type operating over a wide spectral range, the author proposes a single-component four-lens afocal compensator which corrects spherochromatic aberration and suppresses the secondary spectrum. It consists of a positive biconvex lens (BF28 glass), a negative concavo-plane lens (crystal of potassium iodide), a positive plano-convex lens (BK10 glass), and a negative concavo-plane lens (TK12 glass). The design of such a system is based on aberration calculations, namely determining the four Seidel sums according to laws of geometrical optics. These calculations are simplified by assuming the two middle lenses to be made of the same material and to be so close to one another that they can be regarded as a thin pair. A resolving power of  $70\text{-}100 \text{ mm}^{-1}$  is feasible, with a relative aperture of 1:10 for 16x22 mm frames. For improving the image quality in a system of the second type, the author proposes to arrange the first objective and the intermediate objective as well as the first component of the switching lens into a system symmetric with respect to the plane of aperture stop at the center of the intermediate objective. Design calculations here are based on the same principles, determining the four Seidel sums. The results indicate the feasibility of a resolving power of  $80\text{-}100 \text{ mm}^{-1}$ , with a relative aperture of 1:10 for 16x22 mm frames. Figures 2; references: 3 Russian.

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